Variation in the sea anemone Sagartia Luciæ. GERTRUDE C. DAVENPORT.

Sargartia Luciæ is conspicuously marked by a varying number of orange colored bands which run longitudinally. These orange bands were counted in 751 individuals at Cold Spring Harbor. Their number varied from 0–20. The largest proportion had 12 stripes. Secondary maxima occurred at 8, 4, 1 and 16. Longitudinal division was observed in which the twelve stripes were apportioned to the two resulting individuals as follows: 9–3; 4–8; 5–7. Also such divisions as 3–3; 7–1 were noted. Hence the variation in the number of stripes is dependent upon fission. Division, so far as observed, was aboral-oral and was usually accomplished within of 24 hours. By feeding to repletion, division already begun could be delayed, even apparently prevented. When cut longitudinally into halves regeneration was rapid. Even small fragments artificially obtained reproduced normal individuals. Normal division was observed only in diglyphic types. Monoglyphic individuals are plentiful and occur as the result of division of diglyphic forms. Basal budding and fragmentation are believed to be very common method of multiplication of this species.

Variation studies on Pectinatella magnifica. C. B. DAVENPORT.

The number of spines on the statoblasts of *Pectinatella* from Chicago was counted in over 800 cases. The law of distribution of frequencies was deduced by quantitative methods. The skewness is positive, that is there is an excessive tendency toward large numbers. This fact of variation in the form-unit agrees with the fact that the other races of *Pectinatella magnifica* and the other species of the genus have a larger modal number of spines. The ontogenetic causes of the variation and of abnormalties was considered.

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SOME OF THE PROBLEMS OF LIMNOLOGY.*

IF the object of science is to correlate and state the results of observation in such a way as to produce mental economy, it can hardly be said that limnology has developed very far as a science. It is certainly still true that much of our knowledge regarding lakes is in that condition of 'detailed statement whose mastery involves great mental exertion. Through this stage all sciences have passed and signs are not lacking that limnology will soon reach the position now occupied by older branches of biological science. To secure this result the student of lake life must attempt to solve problems rather than merely to state facts.

Two classes of problems present themselves to the limnologist: the first, scientific; the second, practical. The first comprises the problems raised by the study of the lake as a unit of environment. The second class concerns itself with the question of the lake as a unit of economic production. The answer to the practical question depends on the correct solution of the scientific problems.

In attempting to solve these problems the limnologist finds himself constantly hampered by the lack of knowledge through which he may interpret the results which he reaches. The acquirement of this knowledge seems to me the first and most necessary step toward bringing exactness and comprehensiveness into our views of lake biology. We count the constituents of the plankton, but are not able to state the significance of the results which we reach. Laborious and slow as the process of counting is, I see no escape from the conclusion that it will remain for a long time the only exact way of ascertaining the facts regarding the assemblage of plants and animals which constitute the plankton. For the

* Address in opening discussion on 'Methods and Results of Limnological Work,' at the meeting of Naturalists at Chicago, December 28, 1899.

interpretation of these results more knowledge is necessary. I shall content myself with pointing out a few directions in which this interpretative knowledge must be gained, if the results of observation are to be of real scientific value. First in importance I should place the knowledge of the chemistry of the plankton, from which its possible nutritive value can be learned. The unit system of counting, as advocated by Whipple, is undoubtedly a great advance on mere enumeration, but the units thus employed are not even units of mass, much less units of chemical composition. The difference in the amount of ash between diatoms and crustacea, not to speak of other differences, is so great that no direct comparison, however exact, of cubic contents can teach us the significance of the two groups in the lake's plankton. Chemical analyses only will do this and these must be be stated both in terms of bulk of the centrifuged or settled plankton, and in terms of the average individual plant or animal, as determined by counting. Every limnologist, therefore, should be careful to avail himself of the opportunity presented by the appearance of a monotypic plankton to collect it in sufficient quantities for analysis. I have myself to confess that I have neglected three opportunities of collecting *Daphnia hyalina* in these large quantities. Similar opportunities have no doubt been neglected by many of us, but the necessity of this information is so pressing that I am sure we must all agree in placing it first on the list of desiderata.

It may be possible to collect the ordinary plankton in large quantities and to separate it into its constituents more or less completely by means of one of the centrifugal milk separators. The difference in density between the diatoms, the cyanophyceæ and the crustacea is so great that there ought not to be any serious difficulty in separating the plankton into at least three groups. So far as I am aware, no experiments have been made in this direction, but the work must be attempted and in some way or other we must secure single groups, or, if possible, single species of plankton plants or animals in quantities sufficient for chemical analysis, or our results will continue to suffer from their present indefiniteness.

A second line of investigation which demands much study concerns the biological significance of the constituents of the plankton, especially of the plants. Many observers have noted that certain algæ are eaten more freely by the crustacea than are others, yet no such careful and continued observations have been made as to enable us to make any general statements on the subject. Evidently, however, this work must be done, or even the chemical knowledge gained by analysis will fail to disclose the real interrelations of the plankton plants and animals.

A third point of equally great importance concerns our knowledge of the chemistry of the water of the lakes and of its gaseous contents as related to the plankton. Many waters have been analyzed, yet few or no attempts have been made to correlate these analyses with the nature and abundance of the several plankton species. Still more conspicuously is this true of gas analyses. We suppose, for instance, that in certain lakes the accumulation of the products of decomposition in the deeper waters prevents the animals of the upper regions from descending into the cooler waters of the lake, yet we are at present entirely ignorant of the nature of these products, whether they are gaseous or other, and of the way in which they are able to affect so powerfully the biological conditions of the sub-thermocline. Numerous similar questions are pressing for solution.

A fourth class of questions comprises those raised by the relation of the littoral area to the limnetic region of the lake.

We may be sure, however, that these questions will be very slowly answered, since they open the most complex questions of lake life and those most difficult of solution. We know enough already to be confident that general statements regarding the relation of littoral and limnetic regions are very unsafe. It is true that lakes with steep banks are plankton-poor, yet it does not follow that lakes with large littoral areas are correspondingly rich in plankton. It certainly is not true that lakes are poor in plankton in proportion to their depth, so that even these most simple relations between the shore regions and the deeper water require careful and extended study in order that any safe conclusions may be drawn.

I have contented myself with pointing out a few of the directions in which limnology needs to move if the stock of facts which limnologists are accumulating is to receive an adequate interpretation. In order that such a result may be reached in the future, it is necessary for the student of lakes to propose to himself definite questions and to work as definitely toward their solution. The time has passed when the publication of the limnetic species, or even the quantitative determination of the constituents of plankton can materially further the advance of science. This work was useful, chiefly in disclosing to us the problems of limnology. These are now before us, in part at least, and the time has come when the student of lakes must attempt to answer some of them.

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*A PRELIMINARY ACCOUNT OF SOME OF THE RESULTS OF THE PLANKTON WORK OF THE ILLINOIS BIOLOGICAL STATION.**

THE Illinois River drains an area of 29,000 square miles, is over 500 miles in length, and has at low water a fall of but 31 feet in the last 227 miles of its course. The low gradient is due to the fact that, in a part of its course at least, the present stream and its bottom lands occupy the bed of an ancient outlet of Lake Michigan. The present flood plain is but partially developed—the bank height rarely exceeding 15 feet—and overflows are frequent and extensive. Floods rise from 16 to 24 feet above low water levels, increasing the total extent of water area to over 700 square miles. The impounding action of the bottom lands, the low gradient, and the backwater from the Mississippi River combine to prolong the flood period. The stream at low water is from 500 to 1500 feet in width and three to 12 feet in depth, and by reason of the dams forms a series of slackwater pools with a sluggish current of about one-half mile per hour. The waters of the adjacent lagoons, bayous, and lakes are also shoal and attain a high temperature during the period of summer heat. The water is rich in organic matter being derived from the run-off and seepage of fertile prairie soil and is further fertilized by the sewage of a metropolis and of a score of smaller cities along its banks, in addition to the offal of extensive cattle-yards and large amounts of distillery wastes. Under these conditions it is not surprising that ammonia, nitrites and nitrates are present in excessive quantities. The high temperature and the abundance of nutrition thus favor the development of the aquatic flora and in sequence that of the aquatic fauna.

Quantitative investigations of the plankton have been carried on at somewhat regular and frequent intervals from June, 1894, to April, 1899, in a series of representative localities near Havana, Ill.; (1) the main stream; (2) Spoon River, a typical tributary; (3) Quiver Lake, rich in vegetation much of the time and fed by spring water; (4) Thompson's Lake, a large (6 × .5 miles) open lake, fed by the river and usu-

* Abstract of address in opening discussion on Methods and Results of Limnological work at meeting of Naturalists at Chicago, December 28, 1899.